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**BRL**

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MEMORANDUM REPORT No. 1065

APRIL 1957

**A Revised Drag Coefficient,  $K_D$ ,  
Based On The 8-Inch Howitzer Shell,  
HE, M106**

**CHARLES T. ODOM**

DEPARTMENT OF THE ARMY PROJECT No. SB0307003  
ORDNANCE RESEARCH AND DEVELOPMENT PROJECT No. TB3-0430

**BALLISTIC RESEARCH LABORATORIES**



**ABERDEEN PROVING GROUND, MARYLAND**

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CTOdom/wc  
Aberdeen Proving Ground, Md.  
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ABSTRACT

A drag coefficient,  $K_D$ , based on radio doppler measurements of the 8-inch, HE, M106 Shell, was presented in BRL Technical Note 1041, October 1955. The application of this drag coefficient to full scale range firings indicated that it should be revised before being used in the computations of a firing table for the 8-inch, HE, M106 Shell. The revised drag coefficient, and the ballistic coefficients of the shell with respect to the revised drag are presented in this report, which supersedes Technical Note 1041.

## INTRODUCTION

BRL Technical Note Number 1041, October 1955, presented a drag coefficient,  $K_D$ , of the 8-inch howitzer Shell, HE, M106. This drag coefficient, based on radio doppler measurements of the M106 Shell, was tabulated as a function of the Mach Number,  $M$ . Also given were five analytical expressions, piecemeal fits of the radio doppler drag data used to generate the values of  $K_D$  appearing in the Technical Note. These expressions, when applied to full scale range firings conducted prior to the radio doppler drag tests, produced however, considerable variation about the average form factor so further range firings were planned to supplement the original range data.

The supplemental range firing was completed in December 1955 and application of the five part drag fit of Technical Note 1041 to this firing showed that the sonic and supersonic portions of the fit were adequate in that the higher muzzle velocities produced form factors near unity. The fit in the subsonic portion of the drag curve, however, did not appear to be adequate in that subsonic muzzle velocity range data produced form factors ten to fifteen percent in excess of unity. The subsonic portion of the drag curve was, therefore, adjusted upward to decrease the form factors of shell fired at low muzzle velocities. Following are the adjusted fitting expressions:

In the Interval	$K_D$ is given by
$0 \leq M \leq 0.90$	0.0547117
$0.90 \leq M \leq 0.93116$	$354.2457089M^3 - 956.92875003M^2$ $+861.65467948M - 258.56732794$
$0.93116 \leq M \leq 0.94906$	$191.81088075M^3 - 532.70702879M^2$ $+494.13979376M - 153.03230004$
$0.94906 \leq M \leq 3.0$	$-0.4953449066 + 0.6585549046M$ $-(0.5014967518M^2 - 1.0090404772M$ $+0.5079263485)^{1/2}$

Range data from the additional range firing, reduced using the above expressions, produced the following ballistic coefficients,  $C$ , and form factors,  $i$  which are being used in the preparation of the revised 8-inch howitzer Firing Table 8-J-2:

Charges 1-4, 6 and 7

$\phi \leq 800$ mils	$C = 3.2548, \quad i = .9601$
$\phi \geq 800$ mils	$C = 1.6275 + 0.004083088\phi - 0.00000255143\phi^2$

Charge 5

$\phi \leq 800$  mils

$$C = 3.3229, \quad i = .9404$$

$\phi \geq 800$  mils

$$C = 1.6896 + 0.004083088\phi - 0.00000255193\phi^2$$

The ballistic coefficients above are computed for a standard Shell weight of 200 pounds.

*Charles T. Odom*

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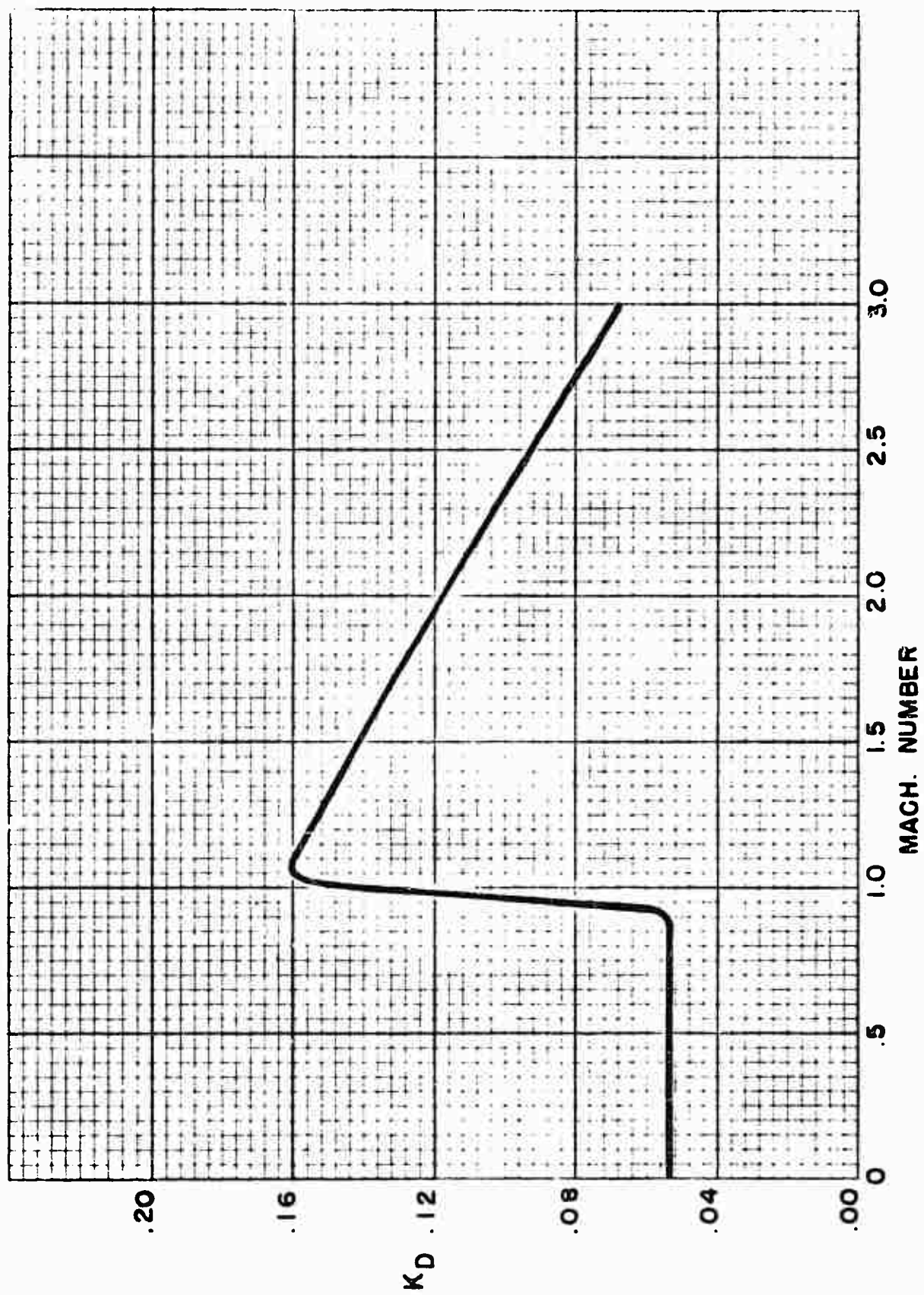


FIG.2 DRAG COEFFICIENT OF 8-INCH SHELL, HE, M106



**TABLE**  
**of**  
**DRAG COEFFICIENTS**

# Drag Coefficients

M	$K_D$	M	$K_D$	M	$K_D$	M	$K_D$
3.000	.068132	2.600	.087943	2.200	.107733	1.800	.127468
2.990	.068627	2.590	.088438	2.190	.108227	1.790	.127960
2.980	.069122	2.580	.088933	2.180	.108721	1.780	.128452
2.970	.069618	2.570	.089428	2.170	.109215	1.770	.128944
2.960	.070113	2.560	.089923	2.160	.109710	1.760	.129435
2.950	.070609	2.550	.090418	2.150	.110204	1.750	.129927
2.940	.071104	2.540	.090913	2.140	.110698	1.740	.130418
2.930	.071600	2.530	.091408	2.130	.111192	1.730	.130909
2.920	.072095	2.520	.091903	2.120	.111686	1.720	.131400
2.910	.072590	2.510	.092398	2.110	.112180	1.710	.131891
2.900	.073086	2.500	.092893	2.100	.112674	1.700	.132382
2.890	.073581	2.490	.093388	2.090	.113168	1.690	.132873
2.880	.074076	2.480	.093883	2.080	.113662	1.680	.133363
2.870	.074572	2.470	.094378	2.070	.114156	1.670	.133854
2.860	.075067	2.460	.094873	2.060	.114649	1.660	.134344
2.850	.075562	2.450	.095368	2.050	.115143	1.650	.134834
2.840	.076058	2.440	.095862	2.040	.115637	1.640	.135324
2.830	.076553	2.430	.096357	2.030	.116131	1.630	.135813
2.820	.077048	2.420	.096852	2.020	.116624	1.620	.136303
2.810	.077544	2.410	.097347	2.010	.117118	1.610	.136792
2.800	.078039	2.400	.097842	2.000	.117611	1.600	.137281
2.790	.078534	2.390	.098336	1.990	.118105	1.590	.137770
2.780	.079030	2.380	.098831	1.980	.118598	1.580	.138258
2.770	.079525	2.370	.099326	1.970	.119091	1.570	.138746
2.760	.080020	2.360	.099821	1.960	.119585	1.560	.139234
2.750	.080515	2.350	.100315	1.950	.120078	1.550	.139722
2.740	.081011	2.340	.100810	1.940	.120571	1.540	.140209
2.730	.081506	2.330	.101305	1.930	.121064	1.530	.140696
2.720	.082001	2.320	.101799	1.920	.121557	1.520	.141182
2.710	.082496	2.310	.102294	1.910	.122050	1.510	.141669
2.700	.082992	2.300	.102788	1.900	.122543	1.500	.142154
2.690	.083487	2.290	.103283	1.890	.123036	1.490	.142640
2.680	.083982	2.280	.103777	1.880	.123529	1.480	.143125
2.670	.084477	2.270	.104272	1.870	.124022	1.470	.143609
2.660	.084972	2.260	.104766	1.860	.124514	1.460	.144093
2.650	.085467	2.250	.105260	1.850	.125007	1.450	.144576
2.640	.085963	2.240	.105755	1.840	.125499	1.440	.145059
2.630	.086458	2.230	.106250	1.830	.125991	1.430	.145541
2.620	.086953	2.220	.106744	1.820	.126484	1.420	.146023
2.610	.087448	2.210	.107238	1.810	.126976	1.410	.146503
2.600	.087943	2.200	.107733	1.800	.127468	1.400	.146983

# Drag Coefficients

M	K <sub>D</sub>	M	K <sub>D</sub>	M	K <sub>D</sub>	M	K <sub>D</sub>
1.400	.146983	1.180	.157080	1.140	.158633	1.100	.159835
1.390	.147463	1.179	.157121	1.139	.158668	1.099	.159857
1.380	.147941	1.178	.157162	1.138	.158704	1.098	.159878
1.370	.148418	1.177	.157203	1.137	.158739	1.097	.159899
1.360	.148894	1.176	.157244	1.136	.158774	1.096	.159919
1.350	.149369	1.175	.157285	1.135	.158809	1.095	.159938
1.340	.149843	1.174	.157325	1.134	.158843	1.094	.159957
1.330	.150316	1.173	.157366	1.133	.158877	1.093	.159975
1.320	.150787	1.172	.157407	1.132	.158911	1.092	.159993
1.310	.151256	1.171	.157447	1.131	.158945	1.091	.160010
1.300	.151723	1.170	.157487	1.130	.158979	1.090	.160026
1.290	.152189	1.169	.157527	1.129	.159012	1.089	.160041
1.280	.152652	1.168	.157567	1.128	.159045	1.088	.160056
1.270	.153113	1.167	.157607	1.127	.159078	1.087	.160069
1.260	.153571	1.166	.157647	1.126	.159111	1.086	.160082
1.250	.154026	1.165	.157687	1.125	.159143	1.085	.160094
1.240	.154477	1.164	.157727	1.124	.159175	1.084	.160106
1.230	.154925	1.163	.157766	1.123	.159206	1.083	.160116
1.220	.155368	1.162	.157805	1.122	.159238	1.082	.160125
1.210	.155806	1.161	.157845	1.121	.159269	1.081	.160134
1.200	.156238	1.160	.157884	1.120	.159300	1.080	.160141
1.199	.156280	1.159	.157923	1.119	.159330	1.079	.160147
1.198	.156323	1.158	.157961	1.118	.159360	1.078	.160152
1.197	.156366	1.157	.158000	1.117	.159390	1.077	.160156
1.196	.156408	1.156	.158038	1.116	.159419	1.076	.160159
1.195	.156451	1.155	.158077	1.115	.159448	1.075	.160161
1.194	.156493	1.154	.158115	1.114	.159477	1.074	.160161
1.193	.156536	1.153	.158153	1.113	.159505	1.073	.160160
1.192	.156578	1.152	.158191	1.112	.159533	1.072	.160158
1.191	.156620	1.151	.158229	1.111	.159561	1.071	.160154
1.190	.156663	1.150	.158266	1.110	.159588	1.070	.160149
1.189	.156705	1.149	.158304	1.109	.159615	1.069	.160142
1.188	.156747	1.148	.158341	1.108	.159641	1.068	.160134
1.187	.156789	1.147	.158378	1.107	.159667	1.067	.160124
1.186	.156830	1.146	.158415	1.106	.159692	1.066	.160112
1.185	.156872	1.145	.158452	1.105	.159717	1.065	.160099
1.184	.156914	1.144	.158488	1.104	.159742	1.064	.160083
1.183	.156955	1.143	.158525	1.103	.159766	1.063	.160066
1.182	.156997	1.142	.158561	1.102	.159789	1.062	.160046
1.181	.157038	1.141	.158597	1.101	.159812	1.061	.160025
1.180	.157080	1.140	.158633	1.100	.159835	1.060	.160001

# Drag Coefficients

M	K <sub>D</sub>	M	K <sub>D</sub>	M	K <sub>D</sub>	M	K <sub>D</sub>
1.060	.160001	1.020	.154880	.980	.123503	.940	.074224
1.059	.159975	1.019	.154538	.979	.122348	.939	.073129
1.058	.159946	1.018	.154177	.978	.121183	.938	.072050
1.057	.159915	1.017	.153796	.977	.120010	.937	.070984
1.056	.159881	1.016	.153394	.976	.118828	.936	.069931
1.055	.159844	1.015	.152970	.975	.117639	.935	.068891
1.054	.159805	1.014	.152524	.974	.116442	.934	.067861
1.053	.159762	1.013	.152054	.973	.115238	.933	.066840
1.052	.159716	1.012	.151561	.972	.114028	.932	.065828
1.051	.159667	1.011	.151043	.971	.112811	.931	.064823
1.050	.159614	1.010	.150500	.970	.111588	.930	.063863
1.049	.159557	1.009	.149932	.969	.110360	.929	.062966
1.048	.159496	1.008	.149338	.968	.109126	.928	.062129
1.047	.159431	1.007	.148718	.967	.107887	.927	.061351
1.046	.159362	1.006	.148072	.966	.106644	.926	.060629
1.045	.159288	1.005	.147400	.965	.105396	.925	.059962
1.044	.159210	1.004	.146701	.964	.104143	.924	.059346
1.043	.159126	1.003	.145976	.963	.102886	.923	.058781
1.042	.159037	1.002	.145226	.962	.101626	.922	.058264
1.041	.158942	1.001	.144450	.961	.100361	.921	.057793
1.040	.158842	1.000	.143649	.960	.099094	.920	.057365
1.039	.158735	.999	.142824	.959	.097822	.919	.056979
1.038	.158621	.998	.141975	.958	.096548	.918	.056632
1.037	.158500	.997	.141103	.957	.095270	.917	.056323
1.036	.158372	.996	.140208	.956	.093989	.916	.056049
1.035	.158236	.995	.139292	.955	.092706	.915	.055808
1.034	.158092	.994	.138355	.954	.091420	.914	.055598
1.033	.157939	.993	.137398	.953	.090131	.913	.055417
1.032	.157776	.992	.136422	.952	.088840	.912	.055262
1.031	.157604	.991	.135427	.951	.087547	.911	.055132
1.030	.157421	.990	.134415	.950	.086251	.910	.055025
1.029	.157228	.989	.133387	.949	.084954	.909	.054938
1.028	.157023	.988	.132342	.948	.083670	.908	.054869
1.027	.156805	.987	.131282	.947	.082412	.907	.054816
1.026	.156575	.986	.130208	.946	.081178	.906	.054777
1.025	.156331	.985	.129121	.945	.079967	.905	.054750
1.024	.156073	.984	.128020	.944	.078779	.904	.054733
1.023	.155799	.983	.126908	.943	.077612	.903	.054723
1.022	.155510	.982	.125783	.942	.076464	.902	.054718
1.021	.155204	.981	.124648	.941	.075335	.901	.054718
1.020	.154880	.980	.123503	.940	.074224	.900	.054718
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